

CAR CRASH ANALYSIS - A REVIEW

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ABSTRACT

Passive vehicle crash tests have been standardized for crashworthiness analysis. Additional safety equipment is also incorporated to protect occupants. Pre-crash braking is able to reduce the severity of accident. Anti-collision device and emergency operations make use of controlling speed or stopping before collision in railway operation. Potential of pre-crash braking needs to be analysed further.

KEYWORDS: Car Crash, Collision, Crashworthiness, Simulation, Dummies & Pre-Crash Braking

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1. INTRODUCTION

The ability of a vehicle's structure to protect its occupants during an impact is known as crashworthiness. The structure of an automobile is such that, it absorbs impact energy by controlled plastic deformation in controllable manner and preserves a space for survival. In addition, airbags, anti-lock braking system and traction control are being used as safety features. Vehicle crash tests [1] are conducted to assess the safety of occupants and pedestrians.

Crash Simulation is a way to test the crashworthiness of the car body virtually by using various simulation software. The advantage of crash simulation over real crash is that the same model can be used again and again to check the different parameters involved in crash analysis with different materials and scenarios.

Important parameters are steering wheel intrusions, occupant space and the occupants subjected to deceleration levels. These are governed by legal crash simulation regulations. Crash simulation to create real life situation also include use of crash test dummies and passive safety devices such as seat belts, air bags,

shock absorbers, Anti-lock brake system and dash board.

The types of crash test [1] that is conducted in the present day by different assessment programs for assessing crashworthiness worldwide is given table 1.

Table 1: Programs for Assessing Crashworthiness

S. No.	Region	Name
1	Europe	EuroNCAP (New Car Assessment Program)
2	USA	NHTSA (National Highway Traffic Safety Administration)
3	Australia, New Zealand	ANCAP
4	Latin America	LATIN NCAP
5	China	C-NCAP
6	Germany	ADAC (Allgemeiner Deutscher Automobil-Club).

Various conditions of test include a vehicle and an obstacle or between two vehicles. The collision can be frontal, side and rear. To assess injury of occupant dummies are used. Test speed ranges are from 29kmph (18mph) to 64kmph (40mph).

2. TESTS AND SIMULATIONS

Mnyazikwiye et al [2] and Pawlus et al [3] have used mathematical models and estimated physical parameters (stiffness and dampers). Models were validated with experimental results from real crash tests. Jain et al [4, 5] have done the crash simulation on Ansys v14. The analysis included use of different materials. Full frontal impact simulation was done at a speed of 33.33m/s; the parameters predicted were total deformation, elastic strain and equivalent stress. They concluded that the Steel V-250 has the maximum stress and polycarbonate gave the least value.

Ambati et al [6] have simulated a frontal impact of a Chevrolet C1500 pick-up truck model, moving with a velocity of 56.3kmph in to a rigid immovable barrier. They used LS-DYNA for this simulation. In this simulation, the bumper, engine and the rails absorbed most of the energy before the wheel impacts the wall, and half the energy of the crash is absorbed by these components after about 0.04sec of the crash initiation. In this simulation, two models were used. Model 1 was similar to physical test model of NCAC (National Crash Analysis Centre) model and model 2 had lighter material. Figure 1 shows energy balance graphs. Maximum value of K.E. was 239.126 kJ for model 1 and 208.30 kJ for model 2. Deceleration vs. time variations is shown in figure 2. The maximum value of deceleration for model 1 and model 2 were 98.94g and 84.83g, respectively. Variation of velocity with time is shown in figure 3.

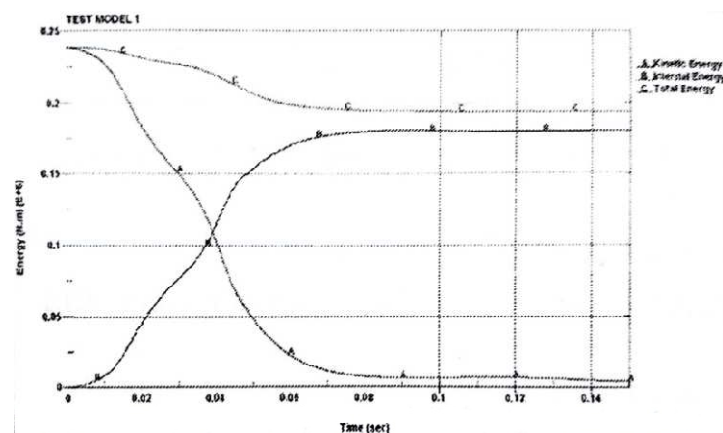


Figure 1: Kinetic Energy, Internal Energy Variation During Crash [6] of Model 1

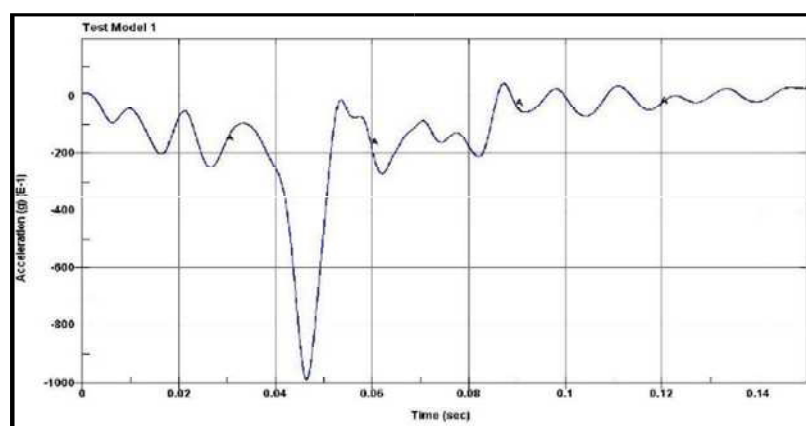


Figure 2: Acceleration vs. Time for Model 1 [6]

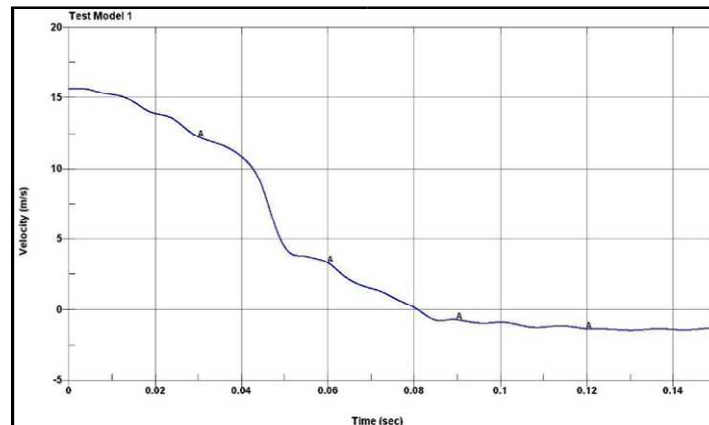


Figure 3: Velocity vs. Time for Model 1 [6]

Andrew and Xiao [7] modeled 2002 Ford Explorer and simulated crash in Ansys. Incoming speeds used were from 20mph to 100mph in increments of 20mph. The total forces and the maximum deformations after impact at various speeds are shown in figure 4.

Total deformation at 20 mph was 10.9”, but nothing that would cause any harm to occupant. Whereas, a crash at 100mph will leave a car totaled and will result in fatality as shown in Figure 5. The length of this vehicle was 180” and deformation was 73.44”, which is about 40% of the total length. Discovery channel’s Myth Busters performed a real impact test on a car, similar to this simulation. In Myth busters’ car testing, a car travelled at 100mph into a wall. These results, at impact, show that the car nearly deformed half of its length.

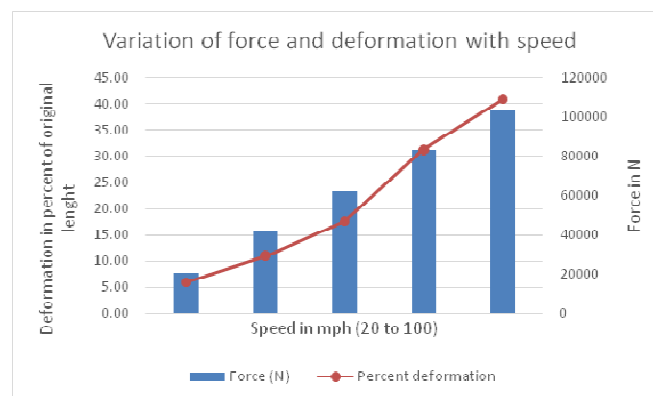


Figure 4: Force Magnitudes and Maximum Deformations at Various Car Speeds

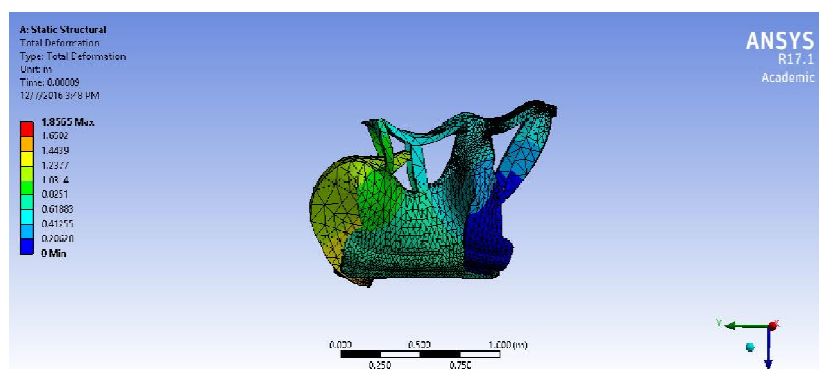


Figure 5: Total Deformation of Car at 100 kmph [7]

3. PRE-CRASH BRAKING [8]

In the foregoing paragraphs, the entire crash analysis considers a driver, a passive system. Crash tests serve [8] to test and evaluate the passive safety of a vehicle, covering deformation zones, occupant cell as well as the seat belts and airbags, whereas, a driver in actual practice is an active member of the system, who attempts to use steering and brakes to avoid or reduce the impact of an accident. Drivers and passengers crash response behavior is important. In order to be able to reproducibly test and evaluate the effects of relevant systems in crash tests according to the holistic approach of integrated safety, the pre-crash reactions of the vehicle must be initiated in a realistic manner, well before the impact with the barrier.

3.1. Anti-Collision System on Railways

On railways [9], which are a guided vehicle and an engine driver does not use steering, are equipped with anti-collision devices to automatically brake or control the speed. One typical system is shown in figure 6; it relies on GPS satellites for positioning updates.

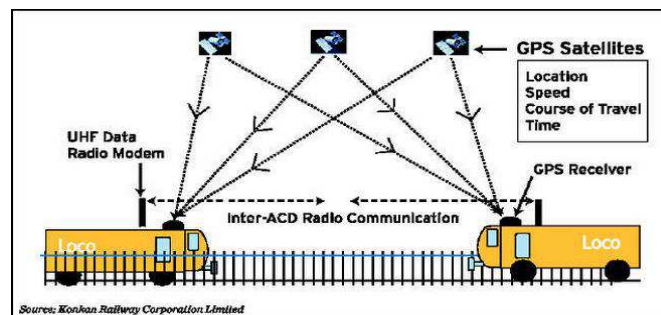


Figure 6: Anti-Collision Device Systems [9]

The active safety features such as effect for stability and braking (ESC and BAS) are analysed in separate driving tests. So, no other standard for tests exists on the extended effect of active safety systems on passive systems.

3.2. Effect of Pre-Crash Braking [8]

Table 2: Effect of Deceleration on Velocity and Kinetic Energy

Deceleration m/s/s	Velocity m/s	Kinetic Energy kJ
0	64	332
1	60.4	296
2	56.8	261
3	53.2	229
4	49.6	199
5	46	171
6	42.4	145
7	38.8	121
7.8	35.92	104
8	35.2	100
9	31.6	81
9.81	28.684	67
10	28	64
11	24.4	48
12	20.8	35
13	17.2	24

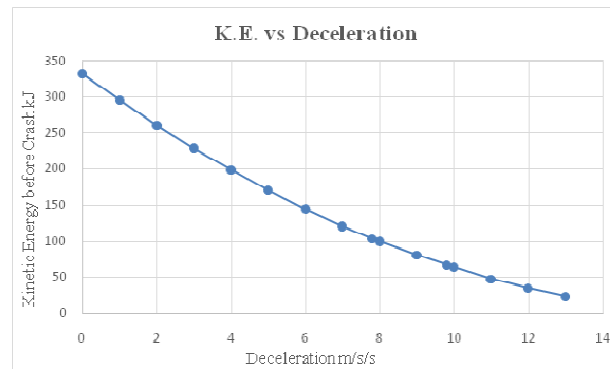


Figure 7: Variation in Kinetic Energy with Pre-Crash Braking

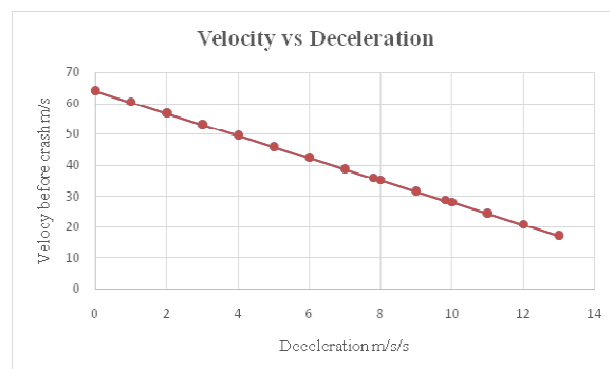


Figure 8: Variation in Velocity Due to Different Level of Deceleration

A moving vehicle possesses kinetic energy, and the severity of a road accident depends on it. Therefore, pre-crash braking can reduce kinetic energy and also the severity of accident. Table 3 gives the variation of velocity for various values of deceleration acting 1 second before the crash and corresponding velocity. Initial velocity before braking is taken 64 kmph. It also shows the corresponding kinetic energy for a vehicle of mass 2,100 kgs. These are shown in figures 7&8.

Reduction in kinetic energy due to pre-crash braking is equivalent to virtual deformation zone [8] and remaining is absorbed by mechanical deformation zone.

3.3. Frontal Impact Test with Pre-Crash Braking[8]

This test was conducted according to Euro NCAP (unbraked) with a starting speed of 64 kmph and 40% overlap with a vehicle having a mass of 2,164 kg. Belted dummies were used for driver and front passenger. Emergency braking was initiated 0.9 seconds before crash. It reduced the speed from 64 kmph to 40.4 kmph and corresponding reduction in kinetic energy was from 352 kJ to 136 kJ before collision with the barrier. There was a lateral deviation of 2 mm and dipping of impact point by 35 mm due to braking.

3.3.1. Occupant Injury[8]

Pre-crash braking has reduced the speed resulting in reduction in kinetic energy before impact. It resulted in the reduction in head injury of driver by 76% and passenger by 78%. It was due to 22% deceleration of driver dummy and 47% for front passenger dummy.

3.4. Tests with A-HBM [10]

Simulated tests were conducted [10] with active human body model (called SAFER A-HBM). It had the capability

to simulate emergency braking events before a crash event. There was a reduction in accelerations by 15–45%, in case of occupant dummy and 60–70% by pre-braking from 64 km/h to 56 km/h and 39 km/h, respectively.

4. CONCLUSIONS

Pre-crash braking affects the severity of impact. Deceleration level reduction causing injury has come down, appreciably. This aspect has not been considered in any of the standards. In rail transport, anti-collision device working in emergency conditions at controlled speed of 15 kmph are in vogue.

Simulation and experimental work needs to be done on reducing the effect during crash, which will enhance the safety of the occupants.

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